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A NOVEL APPROACH FOR WAKEFIELD MEASUREMENTS AT THE ETF

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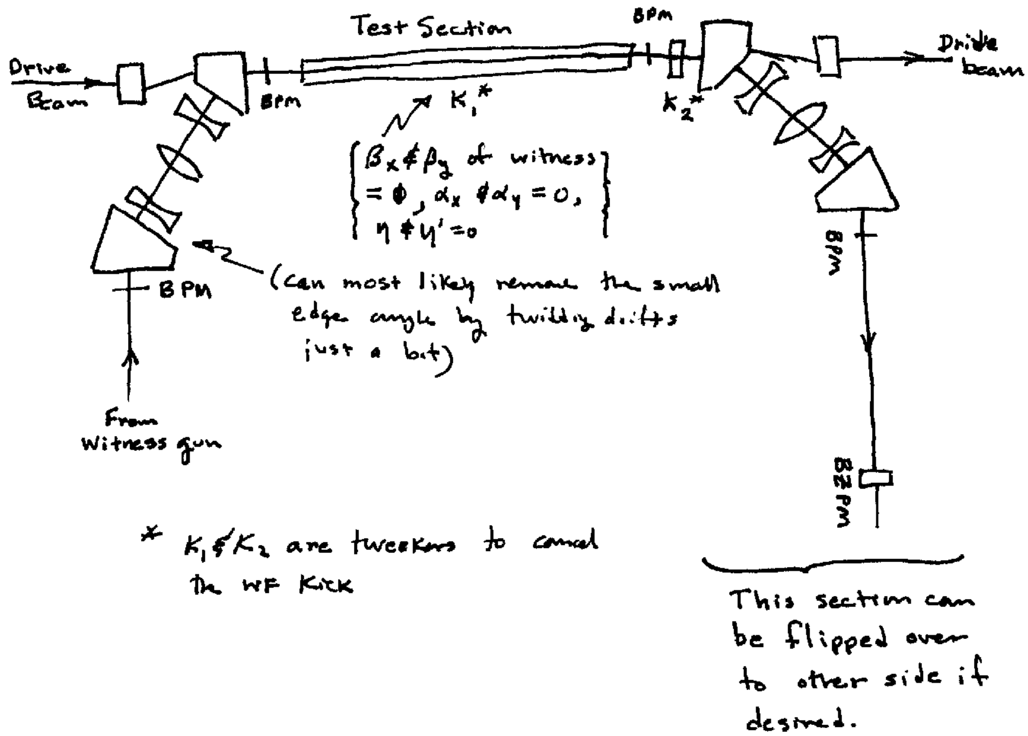
It has been suggested [1] that a wakefield measuring system could be implemented at the ETF to provide high-resolution studies of wakefields in structures. In this note I outline such a system and propose a new measuring technique.

Because this is an informal note and hopefully distributed among friends, I'll use the following messy hand sketch to illustrate the idea.



Beam from the low emittance witness gun is combined with the high energy ETF main beam by optics as shown on the left. Although the indicated bends (for which I actually use 30deg magnets) are achromatic, a narrow slit could be placed in the center quad of the first triplet to better define the momentum. The witness and drive beams would be independently adjusted so as to be collinear in the absence of wakes using the BPMs located at each end of the test section. Note there is a weak Helmholtz dipole along the whole length (approx.) of the device under test. Downstream optics separate the witness and drive beams, and deliver the witness beam to what I'll call a beam-zero position monitor (BZPM).

What the heck is a BZPM you say? Well, I contend that is it is far simpler to construct a sensitive null detector (produces zero output when beam arrives at some well defined position) than it is to construct a calibrated high-resolution position detector. Furthermore, a null is basically insensitive to beam intensity.

Assuming all the above, the procedure for measuring deflection wakes would be something like:

1. Fiddle around to make the bends achromatic and have waists at the mid-point of the test section and at the BZPM
2. Adjust the main and witness beams to separately have the same trajectory through the test section. Next, offset the test device some amount from that line (say by a few mm).
3. With no main beam, position the BZPM to produce null output.
4. With main beam ON and at some selected beam-witness delay, tweak the Helmholtz magnet to move the witness back to the null position.
5. Repeat step 4 using different beam-witness delays.

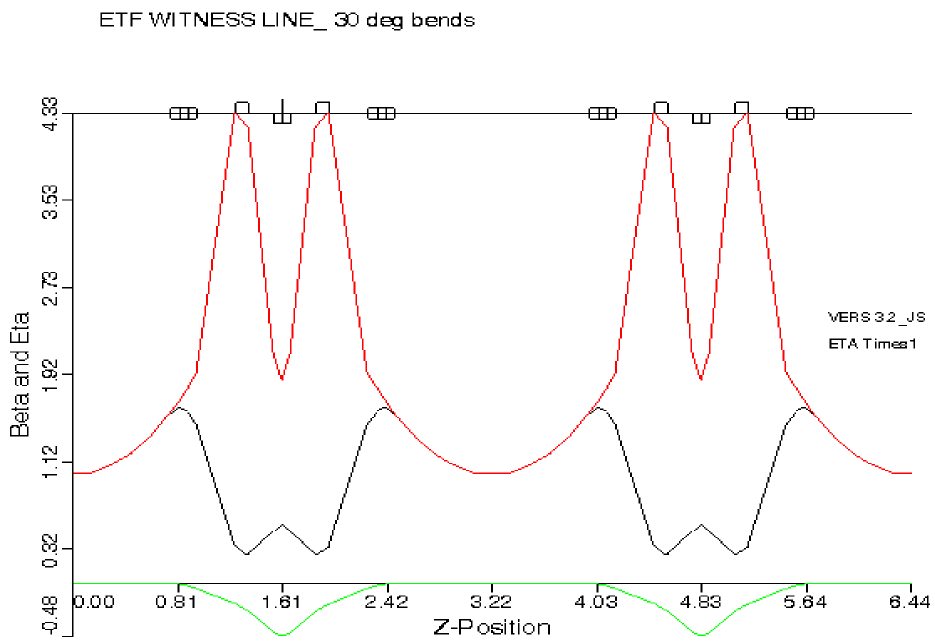
The idea here is that the Helmholtz dipole is being adjusted at each step so as to cancel any deflecting wake, and hence the dipole excitation is a measure of such wakes. An additional advantage of this approach is that the witness beam remains approximately collinear with the driver, closely resembling the real case for high-energy beams.

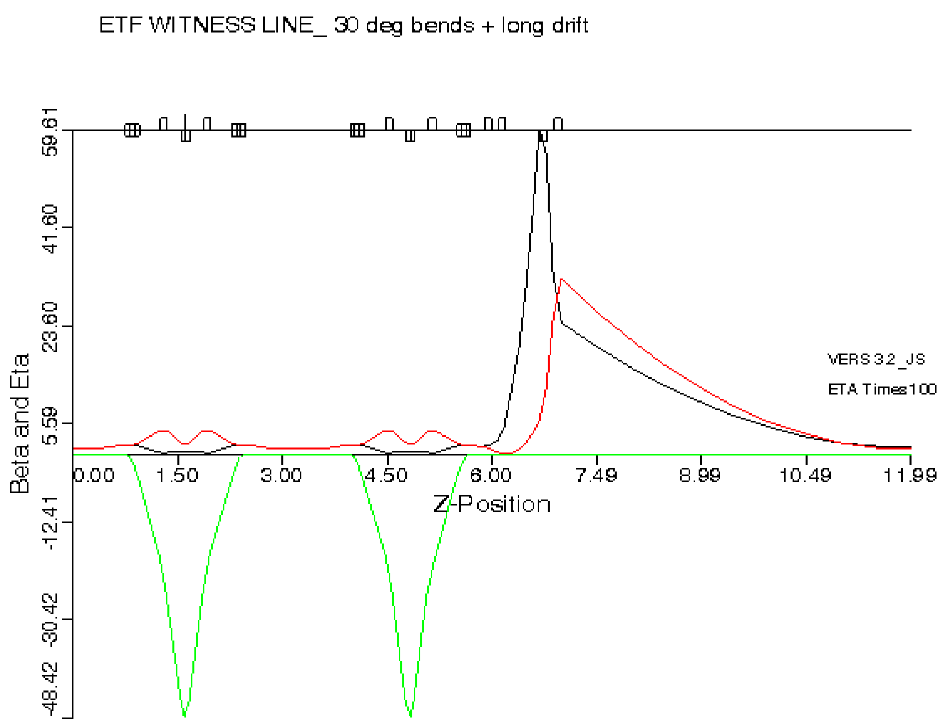
Longitudinal wakes could be measured by placing a suitable spectrometer behind the BZPM. Here, I would have the bend plane of the spectrometer be perpendicular to that of the achromatic bends discussed above. This would tend to decouple any residual angles (e.g. achromatic errors) entering the spectrometer from the actual momentum measurement.

I have done some preliminary design of possible beam optics. Consider, for example, the optics shown at the top of the next page. This has straightforward waist-to-waist sections, with assumed $\beta = 1$ [m] at the ends at the test section midpoint. The transfer matrix from the midpoint to the end has as its element M_{12} at value slightly less than unity. Hence, a micro-radian kick by a test device would produce about a micron displacement of the beam at the BZPM. This should be detectable and correctable by using a Helmholtz tweak.

It has been suggested that a long final drift be used to enhance the angular sensitivity. Although I have not spent a great deal of time trying, I have not been able to realize any substantial improvement even when using a 5 [m] final drift. (See the second optics layout on the following pages.) By the way, I'll leave it as an exercise for the reader to figure out which trace is what on these plots.

What might a BZPM be? It might be an ion chamber in which the usual segmented wire plane is replaced by two plates separated by a narrow space. Perhaps a thin insulating strip could be placed on edge to prevent electrons and ions from "mixing" between the two halves. Again, I haven't spent much time designing a BZPM, but I have no doubt that such a device can have higher resolution than that of othe BPMs.





Summarizing, I suggest a novel scheme by which to accurately measure deflecting wakes in structures. The distinguishing feature of the technique is that an external field is used to cancel deflecting wakefields. Cancellation is detected using a sensitive null detecting position monitor. I contend that a null detector can have increased positional sensitivity over conventional devices, and that greatly reduces intensity dependent uncertainties.

Details such a actual beam intensities and energies are yet to be decided.

1. A high resolution wakefield measurement system for the ETF, Wei Gai and Paul Schoessow, WF-199, 23 June 2000